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Fractal Image Encoding:
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NETROLOGIC, Inc.

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FRACTAL IMAGE ENCODING

Quarterly Progress Report 11-25-91

1. SUMMARY OF WORK. During the period August-November, 1991 we concentrated our efforts in three areas, development of applications, algorithm development and theory. Progress in algorithm development and in seeking commercial partners is encouraging. We are also continuing to evaluate hardware needs.

2. APPLICATIONS. We have selected two specific applications for our compression algorithms. These are distribution of images on CD-ROMS, and inclusion of images of structures in cartographic data bases. The eventual markets include PC-based multimedia, real estate and civil engineering firms. We have prepared a demonstration disk for 386 and 486 machines and SUN workstations, and are currently soliciting evaluations. We have begun to work with a CD-ROM distributor to adapt our software to his needs.

2.1. The demonstration disk. The demonstration program consists of a brief explanation of the fractal encoding concept and a display of greyscale images. The demo runs on IBM compatible computers, but code is also provided bor SUN workstations. The images include high altitude photographs of airfields, fingerprints and images of natural scenes and people.

3. ALGORITHMS. Our system development work is still concentrated in the area of algorithms. The major portion of our effort has been directed toward increasing the efficiency of our present algorithms and development of color encoding capabilities. We have been able to increase decoding speeds significantly. We are also developing coding techniques to be used in conjunction with the wavelet transform.

3.1. Color Image Coding. The encoding of color has proven to be a complex issue. Typically, images are stored as indexes

to a color look-up table. This means that an 8 bit per pixel image can contain 256 colors from a palette which contains (typically) about 2^{24} colors. Encoding such images is usually done by expanding the data to RGB representation, converting this representation to the YIQ representation, (which is usually employed for color TV transmission), and encoding the three YIQ signals separately. The advantage of this scheme is that the I and Q signals can be stored very compactly, with little perceptual degradation. The disadvantage is that 3 images must be encoded.

We have implemented this algorithm, but have not felt sufficiently satisfied with its performance to include it in the demonstration package. At the same time we have pursued a different method based on internal ordering of the color look up table which corresponds to image features. This method appears promising, but is not yet viable.

3.2. Optimization of Algorithms. We have improved our encoding algorithm by including algorithms previously developed at UCSD and NOSC. These include classification of the image partitions so that self similar correlation times could be reduced by reducing the set of sub-images searched. The classification algorithm consists of two steps. The first is a classification based on the brightness levels of the four quadrants of a sub-image and the second is based on the contrast of these quadrants. The first level has been implemented and the second is currently being implemented.

3.4. Alternative Fractal Decomposition. The current fractal algorithm has several shortcomings that we hope will be resolved in a generalization of the method. While the current method is quad-tree based, using square partitions of an image, work in rectangular and triangular decomposition is progressing well. In fact, the rectangular decomposition frequently outperforms the current algorithm, but we have

chosen not to implement it because the triangular scheme offers hope of even better performance.

3.3. **Wavelets.** We are currently developing fast wavelet transforms for pre-processing images. During September and October we concentrated upon quadrature mirror filters based on compactly supported wavelets. So far we have developed code for calculating the general scaling coefficients in the one dimensional case and have developed code for calculating transforms based on the product of one dimensional compactly supported wavelets.

4. **THEORY.** We are currently investigating the problem of finding efficient wavelet bases for the pre-processing step. One particular issue is finding transforms which are essentially two-dimensional. This problem is the same as characterizing polynomial maps from the two dimensional torus to a unitary group (Lawton and Resnikoff, 1991) and is related to Serre's conjecture (Lam, 1978). We are also investigating the use of the wavelet transform to reduce the computations necessary for finding correlations between sub-images.

5. **CONFERENCES AND PUBLICATIONS.** We are currently preparing a paper on the triangular coding scheme. We are also preparing a paper for presentation at the SPIE/IS&T Symposium on Electronic Imaging to be held in San Jose, CA, February 9-14.

REFERENCES

W. M. Lawton and H. L. Resnikoff, Multidimensional Wavelet Bases, Aware, Inc., Contract Report, AFOSR Contract No. F49620-89-C-0125, Cambridge, MA, 1991.

T. Y. Lam, Serre's Conjecture, Springer-Verlag, New York, 1978. (Springer Lecture Notes in Mathematics, Volume 635).